

# Course “Urban Thermodynamics”

**Instructors:**

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**Instruction Language:** English

**Semester:** BA5

**Credits:** 3

**Schedule:** Fridays, classroom **CH B3 30** (13:15-16:00)

**SUMMARY:**

Urban settlements are complex human-made systems where interaction between the outdoor environment, structures, and humans follow physical laws of thermodynamics. Therefore, this course introduces the analysis of urban neighborhoods from a thermodynamics perspective, considering the heat exchange between different urban elements such as buildings, vegetation, blue areas, ground, and the surrounding environment. The complex interaction of all urban factors is presented considering a case study neighborhood at EPFL. Special attention is paid to the Urban Heat Island effect and mitigation strategies. In addition, the direct and indirect effect of the outdoor environment on the comfort of humans is discussed.

**CONTENT:**

- Analysis of urban physical processes at various scales
- Features of the urban environment and urban micro-meteorology
- Thermal interactions among the environment, buildings, vegetation, ground, and water surfaces
- Spatial distribution and dynamics of airflow, temperature, and humidity in urban areas
- Influence of materials and urban design on thermal heat exchange and the environmental quality
- Impact of urban elements on urban climate and outdoor comfort

**KEYWORDS:**

Urban heat exchange, built environment, urban heat island effect, outdoor comfort, climate-sensitive urban design

**LEARNING OUTCOMES:**

By the end of the course, the student must be able to:

- Evaluate various modes of heat transfer in the urban environment
- Assess surface energy balance at various urban interfaces
- Carry out thermodynamic analysis at the urban scale
- Critique the choice of urban materials and design and propose alternative solutions
- Examine the effect of the outdoor built environment on human comfort

**ASSESSMENT METHOD:**

- **Course project I** (individual work) - 50%
- **Course project II** (group work) - 50%

**ASSESSMENTS:**

- *Detailed descriptions will be provided in separate documents*
- *Webtool required:* <https://citytherm.epfl.ch/>

**DETAILED SCHEDULE:**

Week	Date	Time	Topics	Instructor
1	12.09	2 x 45'	<b>Course overview:</b> content, evaluation, topics <b>Urban characteristics, Urban Heat Island (UHI) effect</b>	DK
		1 x 45'	Introduction to the web tool <b>CityTherm</b> (part I)	DK
2	19.09	1 x 45'	<b>Overview of physical parameters</b>	DK
		1 x 45'	<b>Introduction to the course project I</b>	DK, JY
		1 x 45'	Supervised work on the course project I	JY
3	26.09	2 x 45'	<b>Heat Transfer: Conduction and radiation</b>	DK
		1 x 45'	Supervised work on the course project I	JY
4	03.10	2 x 45'	<b>Heat Transfer: Convection and evaporation</b>	DK
		1 x 45'	Supervised work on the course project I	JY
5	10.10	1 x 45'	<b>Campus walk:</b> exploring urban thermodynamics	DK, JY
		2 x 45'	Supervised work on the course project I	JY
6	17.10	3 x 45'	Supervised work on the course project I <b>Course project I submission deadline: 16:00 on October 17</b>	JY
7	24.10		<b>BREAK</b>	
8	31.10	1 x 45'	<b>Urban modeling and computational tools</b>	JY
		1 x 45'	Introduction to the web tool <b>CityTherm</b> (part II)	JY
		1 x 45'	<b>Introduction to the course project II</b>	JY
9	07.11	2 x 45'	<b>Building-environment interaction:</b> thermal, aerodynamic, and hydrodynamic interaction	DK
		1 x 45'	<b>Supervised group work - course project II</b>	JY
10	14.11	2 x 45'	<b>Ground-environment interaction:</b> ground properties, thermal, aerodynamic, and hydrodynamic interaction	DK
		1 x 45'	<b>Supervised group work - course project II</b>	JY
11	21.11	2 x 45'	<b>Water body - environment interaction:</b> thermal, aerodynamic, and hydrodynamic interaction	DK
		1 x 45'	<b>Supervised group work - course project II</b>	JY
12	28.11	2 x 45'	<b>Vegetation – environment interaction:</b> characteristics of vegetation, evapotranspiration, aero- and thermal interaction	DK
		1 x 45'	<b>Supervised group work - course project II</b>	JY
13	05.12	2 x 45'	<b>Human Outdoor Comfort:</b> Parameters affecting human comfort and comfort indices (UTCI, PET)	JY
		1 x 45'	<b>Supervised group work - course project II</b>	JY
14	12.12	1 x 45'	<b>Climate-Sensitive Urban Design:</b> complex interaction of all urban elements and their effect on UHI and outdoor comfort	DK
		2 x 45'	<b>Supervised group work - course project II</b>	JY
15	19.12	3 x 45'	Supervised group work on the course project II <b>Course project II submission deadline: 16:00 on December 19</b>	DK, JY

**MAIN REFERENCES:**

- T.R. Oke, G.Mills, A. Christensen, J.A. Vooght, **Urban Climates**, Cambridge University Press
  - *ebook (PDF file) is available [here](#), 3 printed copies are available in the library*
- S. Medved, **Building Physics: Heat, Ventilation, Moisture, Light, Sound, Fire, and Urban Microclimate**, Springer
  - *ebook (PDF file) is available [here](#), 1 printed copy is available in the library*
- A. Rodrigues, R.A. Sardinha, G. Pita, **Fundamental Principles of Environmental Physics**, Springer
  - *ebook (PDF file) is available [here](#), no printed copy is available in the library*
- N. Mason, P. Hughes, **Introduction to Environmental Physics: Planet Earth, Life and Climate**, Taylor & Francis
  - *ebook (PDF file) is available [here](#), 1 printed copy is available in the library*